frontiers | Frontiers in Sustainable Food Systems

TYPE Editorial
PUBLISHED 02 July 2024
DOI 10.3389/fsufs.2024.1449487

OPEN ACCESS

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RECEIVED 15 June 2024
ACCEPTED 24 June 2024
PUBLISHED 02 July 2024

CITATION
Shi K, Han J, Xia X and Liu H (2024) Editorial: The hazards and nutritional benefits of metal(loid)s in food and environment. *Front. Sustain. Food Syst.* 8:1449487. doi: 10.3389/fsufs.2024.1449487

Editorial: The hazards and nutritional benefits of metal(loid)s in food and environment

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KEYWORDS

cadmium, chromium, strontium, microbial agent, termite nest, nutritional quality evaluation, non-communicable diseases

Editorial on the Research Topic
The hazards and nutritional benefits of metal(loid)s in food and environment

Metals play a crucial role in facilitating the sustainable development of ecological agriculture. The presence of toxic metals, such as cadmium (Cd) and chromium (Cr), in the environment can have detrimental effects on crop growth, resulting in reduced yield and compromised quality. This not only impedes the long-term progress of agriculture but also poses a significant threat to food safety. Accumulation of metals in the human body primarily occurs through dietary intake, potentially leading to various diseases. Conversely, deficiencies in essential elements like strontium (Sr) within the human body may also contribute to certain ailments. The objective of this Research Topic is to unveil the hazards to food safety caused by the contamination of soil or water with toxic metals and enhance the presence of beneficial metals in order to raise awareness regarding the nutritional and safety aspects associated with metals. Within this Research Topic, four articles explore novel approaches for reducing Cd or Cr accumulation in plants and elucidating the mechanisms involved in regulating Cd stress in plants. Additionally, two articles investigate new perspectives on the relevance of beneficial metal Sr in inflammation and non-communicable diseases (NCDs), as well as its presence in apples across seven regions in China.

The International Agency for Research on Cancer (IARC) has classified Cd as a Class I human carcinogen, and it has been associated with various health conditions. Therefore, the research should encompass two aspects: investigating the response of crops to Cd and developing effective soil remediation techniques to mitigate Cd absorption Cd by crops. In terms of the response of crops to Cd, Chen et al. investigated the transcriptional changes in both tomato roots and shoots following Cd treatment. Exposure to Cd resulted in an enrichment of various pathways, including glutathione metabolism, sulfur metabolism, phenylpropanoid biosynthesis, cutin pathway involved in plant-pathogen interaction, suberine and wax biosynthesis pathway, as well as photosynthesis-antenna

proteins pathway. In addition, four genes encoding ABC transporter (*Solyc12g013640* and *Solyc07g065320*), an oligo peptide transporter (*Solyc11g012700*), and a high-affinity nitrate transporter (*Solyc11g069735*) were found to be upregulated, while one gene encoding a vacuolar iron transporter (*Solyc01g104820*) was downregulated under Cd stress as verified by quantitative real-time RT-PCR (qRT-PCR). The same observations were made in *Brassica rapa* L. by Fan et al., suggesting that the involvement of zinc transporters and the biosynthesis of phenylpropane, cutin, suberine, and wax may contribute to resistance against Cd stress. Taken collectively, it is suggested that these genes may exert a pivotal role in the plants' response to Cd-induced stress. However, further investigation is warranted to elucidate the underlying mechanisms of these genes under Cd stress in plants. Furthermore, Qi et al. conducted an investigation on the accumulation and transfer of Cd in five potato varieties (*Solanum tuberosum* L.) and in yellowish-brown and limestone soils. The authors observed a consistent pattern in the distribution of Cd accumulation across different plant parts: roots exhibited the highest levels, followed by stems, leaves, and tubers. Among the five potato varieties tested, Favorita demonstrated the highest capacity for Cd accumulation, followed by Mira, Eshu-12, Huashu-6, and Zhongshu-5. Furthermore, the yellowish-brown soil demonstrated a greater tendency to accumulate Cd and a lower ability to transport it to the plants compared to limestone soil.

Microorganisms present in soil possess the capability to adsorb Cd onto their cell surface through electronegative functional groups and exopolysaccharides (EPS), sequester Cd within cells via metallothionein, or produce hydrogen sulfide (H_2S) for coprecipitation with Cd. Fan et al. conducted a study on the impact of *Stenotrophomonas* strain CD2 in reducing Cd accumulation in *Brassica rapa* L. It was observed that strain CD2 effectively removed 0.1 mmol/L Cd(II) within 36 h by intracellular sequestration and production of biofilm, EPS, and H_2S. When applied to soil contaminated with Cd, strain CD2 exhibited a significant reduction of 51.16% in roots uptake and 55.56% decrease in aboveground tissues. Furthermore, the presence of chromate [Cr(VI)], which is a highly toxic heavy metal element, represents one of the most prevalent sources of wastewater contamination. Therefore, it is necessary to consider approaches for reducing Cr(VI) uptake in plants as well. Wang et al. developed natural biomass materials derived from termite nests (*Coptotermes formosanus* and *Odontotermes formosanus*) for the purpose of adsorbing Cr(VI) ions in wastewater. The maximum adsorption capacities of *C. formosanus* nest and *O. formosanus* nest for Cr(VI) were determined to be 48.52 mg/g and 35.99 mg/g, respectively. Furthermore, the utilization of termite nests effectively reduced the concentration of Cr(VI) in *Brassica chinensis* L.

Following the remarkable increase in global crop yields brought about by the Green Revolution, the focus on addressing hunger has shifted from mere caloric sufficiency to tackling deficiencies in essential micronutrients. Sr, a trace element abundantly present in the Earth's crust, plays a critical yet often underestimated role in various biological processes that impact human health. In their comprehensive review Ru et al. explore the multifaceted implications of Sr, particularly within the context of NCDs. This review provides an intricate understanding of strontium's diverse contribution to human health. The evidence presented herein underscores the significant potential of Sr in influencing various health outcomes, especially in the relation to chronic diseases. Additionally, Hong et al. developed a novel nutritional assessment model based on Sr and other compositional factors in apples across seven regions in China. These authors established two different nutritional evaluation models incorporating traditional sensory attributes (taste, aroma, color, fruit shape), nutritional composition, physical and chemical parameters (soluble sugar, titratable acid, dietary fiber content, soluble solid concentration, vitamin C level, sugar-acid ratio, hard acid ratio), as well as Sr. Based on the analysis of nutritional components conducted in this study, two different nutritional evaluation systems were devised using separate assignment methods. Upon assessment, Yiyuan Red apples consistently ranked highest in terms of their nutritional value which aligns with their Sr content ranking. This finding suggests that Sr content influences the overall nutritional value of apples.

In conclusion, the findings of this Research Topic underscore the response of tomato, potato, and *Brassica rapa* L. to Cd contamination. Additionally, novel microbial agents and termite nests have been developed as remediation materials for addressing Cd or Cr contamination. Furthermore, attention has been given to the role of Sr in inflammation and NCDs, as well as its presence in apples. These studies are expected to enhance our understanding of metals application and make a valuable contribution toward ensuring food safety.

Author contributions

KS: Writing – original draft, Writing – review & editing. JH: Writing – review & editing. XX: Writing – review & editing. HL: Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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